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Income Inequality and Use of Dental Services in 66 Countries

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ABSTRACT

This study explored the association between income inequality and use of dental services and the role that investment in healthcare plays in explaining that association. We pooled individual-level data from 223,299 adults, 18 years or older, in 66 countries, who participated in the WHO World Health Surveys with country-level data from different international sources. Income inequality was measured at national level using the Gini coefficient and use of dental services was defined as having received treatment to address problems with mouth and/or teeth in the last year. The association between Gini coefficient and use of dental services was examined in multilevel models controlling for a standard set of individual and country-level confounders. The individual and joint contributions of four indicators of investment in healthcare were evaluated in sequential modelling. Gini coefficient and use of dental services were inversely associated after adjustment for confounders. Every 10%-increase in Gini coefficient corresponded with 15% lower odds of using dental services (Odds Ratio: 0.85, 95% Confidence Interval: 0.70-0.99). The association between Gini coefficient and use of dental services was attenuated and became non-significant after individual adjustment for total health expenditure, public expenditure on health, health system responsiveness or type of dental health system. The four indicators together explained 80% of the association between Gini coefficient and use of dental services. This study suggests that more equal countries have greater use of dental services. It also supports the mediating role of investment in healthcare in explaining that association.

INTRODUCTION

Income inequality or the uneven distribution of income in a given society has detrimental effects on health (Kondo et al., 2009; Lynch et al., 2004; Subramanian and Kawachi, 2004; Wilkinson and Pickett, 2006). Evidence on the effect of income inequality on oral health comes mainly from ecological and multilevel studies. While initial cross-national comparisons were inconclusive (Bernabé et al., 2009; Bernabé and Hobdell, 2010; Masood et al., 2012; Sabbah et al., 2010), the few multilevel studies conducted to date have shown that greater income inequality is inversely associated with population oral health. Perceived dental health and self-reported tooth loss were, respectively, associated with district-level and state-level income inequality in Japanese and American adults (Aida et al., 2011; Bernabé and Marcenes, 2011), whereas dental caries was associated with municipal-level income inequality in 35-44-year-old Brazilians (Celeste et al., 2011). No multilevel study in dentistry has measured income inequality using larger geographical areas, such as countries.

Income inequality may damage health through different mechanisms: *(i)* via a set of social processes and policies that reduces social spending and public investment, including health care services and public health interventions; *(ii)* by damaging the quality of interpersonal relationships, which then influences the diffusion of health information, the adoption of healthy norms and the provision of social support; and *(iii)* via stress-related processes due to invidious social comparisons, which exert a direct influence on physiological responses and an indirect influence through health-related behaviors (Kawachi and Kennedy, 1999; Lynch and Kaplan, 1997; Wilkinson, 1999). Reduced spending on healthcare could be an important mechanism linking income inequality to oral health because spending in infrastructure and resources are crucial for improving population health. Research into this important area has policy implications as it shows whether improving access to dental services could help ameliorate the negative effects of income inequality on use of dental services, and in turn, population oral health.

Studies in the US showed that the level of spending on social programs was correlated with both income inequality and population health (Dunn et al., 2005; Ronzio et al., 2004). A multilevel study of 33 high-and-middle-income countries showed that income inequality was negatively associated with health expenditure, with unequal countries spending less on health than more equal countries (Elgar, 2010). There is also dental literature supporting the role of investment in public services. Celeste and Nadanovsky (2010) reported that public policy, measured through an ad-hoc composite scale

including policies on education, child's welfare, sanitation and infrastructure, and public dental services at municipal-level explained part of the effect of income inequality on having missing and decayed teeth. Likewise, Bernabé and Marcenes (2011) showed that the relationship between state-level income inequality and self-reported tooth loss was, to some extent, accounted for by the dentist-to-population ratio and the percent of population receiving fluoridated water in the state.

While the research summarized above demonstrates a link between income inequality and oral health, it is possible that income inequality would also affect oral health related behaviors through the same mechanisms, as suggested by the Behavioral Model of Health Service Use (Andersen 2008). This study explored the association between income inequality and use of dental services while examining the mediating effect of investment in healthcare in explaining this association.

MATERIALS AND METHODS

Data sources

Individual-level data from the World Health Survey (WHS) conducted in 2002-2004 were merged with country-level data from different international sources. The WHS aimed to provide valid, reliable and comparable information from 70 participating countries regarding health status and health systems. In each country, the target population was adults 18 years or older living in private households. Participants were selected using multistage stratified cluster sampling with the intention of collecting nationally representative samples. However, in 6 countries (China, Comoros, Congo, India, Ivory Coast and the Russian Federation) the survey was carried out in geographically delimited regions. Sample sizes varied between 1000 and 10,000 between different countries while ensuring the sample was representative of the target population. In each household, one adult was randomly selected using a Kish table after completing a full household roster (Üstün et al., 2003).

Sixty six of the 70 WHS countries (Appendix Table 1) were selected for this study. United Arab Emirates, Mauritius and Zimbabwe were excluded because they did not have information on income inequality whereas Myanmar was excluded for lacking data on national income.

Variables selection

Use of dental services was the outcome measure for this study, which was derived from two connected questions; 'during the last 12 months, did you have any problems with your mouth and/or teeth?' and 'during the last 12 months, did you receive any medical care or treatment from a dentist or

other oral health specialist for this problem with your mouth and/or teeth?' Respondents were considered to have used dental services if they responded affirmatively to the two questions (Bhandari et al., 2014).

The country-level Gini coefficients were obtained from World Bank (2014). Reporting dates varied from country to country but were for the period between 1994 and 2005 because the income surveys –from which Gini coefficients are estimated– are not conducted every year in most countries. For every country, we chose the reporting year that matched as closely as possible the WHS years. Gini coefficient was expressed as a percentage where 0% indicates perfect equality and 100% indicates complete inequality (De Maio, 2007). Values were rescaled so that they represent changes per 10%-increase in the Gini coefficient (Bernabé and Marcenes, 2011; Kondo et al., 2009).

Possible confounders for this study at the individual level were age, sex, education and household wealth. Age was categorized as 18-29, 30-39, 40-49, 50-59, 60-69 and 70 years and above. Education was measured using a 7-point response scale (no formal schooling, less than primary school, primary school completed, secondary school completed, high school or equivalent completed, college/pre-university/university completed, and postgraduate degree completed) and responses collapsed into three categories (primary school, secondary school, and college or above) to enhance comparability across countries. In Turkey, education was collected as years of education and was converted into categories based on the Turkish Ministry of Education classification. Household wealth was based on ownership of a range of household assets such as mobile phone, fixed line phone, bicycle, refrigerator, computer, dish washer, washing machine and a car. Assets were country specific to fit the standard of living and included between 11 to 20 items. An index to quantify the asset variable was created for each country using principal components analysis. We applied the weights of the first component to each person's data giving a continuous asset index (Filmer and Pritchett, 2001; Filmer and Scott, 2012). This index was then categorized into tertiles. A single confounder at a country level was identified; national income based on Gross domestic product (GDP) per capita in US$ for 2000 was obtained from World Bank (2014).

Investment in healthcare was measured with four indicators. Total health expenditure (public and private) as a proportion of GDP and public expenditure on health as a proportion of total health expenditure for 2003 were obtained from WHO (2006). Responsiveness relates to a system's ability to respond to the legitimate non-medical expectations of potential users (Murray and Frenk, 2000)

and it encompasses the notion of an individual's experience of contact with the health system (Valentine et al., 2003). WHO has operationalized the concept through measurement across seven domains related to respect for persons (confidentiality, autonomy and dignity) and client orientation (choice of providers, prompt attention, quality of amenities and access to support networks). A weighted composite score from 0 to 10 was derived for each country, with higher scores denoting higher health system responsiveness (WHO, 2000). Finally, dental care systems were classified into one of four types based on their financing mechanisms: government-organized national social security system or health service (taxation), government-regulated (compulsory) social insurance, private provision and finance, and system containing several key elements of more than one system (mixed), following the classification proposed by Anderson et al. (1998). (Appendix Table 2)

Statistical analysis

A two-level random intercepts and fixed-slopes model structure with individuals nested within countries was fitted, treating use of dental services as a binary outcome. The fixed- and random-parameter estimates for the two-level binomial logit models were calculated using marginal quasi-likelihood (MQL) procedures with first-order Taylor series expansion, as implemented in MLwiN 2.29. All analyses were conducted on the unweighted sample as multilevel modeling incorporating survey design features is a matter of ongoing debate (Cai, 2012; Carle, 2009) and although available in MLwiN it is still considered experimental (Rasbash et al., 2009). However, Rai et al. (2013) showed that almost identical results were obtained in sensitivity analysis for probability weights using the WHS data for cross-country comparison of income inequality and depression.

The modeling strategy was first to estimate the crude association between Gini coefficient and use of dental services, and then adjust for factors that could explain this association. The reason for this strategy was to evaluate compositional and contextual effects when controlling for individual- and country-level confounders, respectively. Indicators for investment in healthcare were then added to the model to evaluate if any residual relationship between Gini coefficient and use of dental services could be further explained. The crude association between Gini coefficient and use of dental services was first reported (labeled as Model 1), and it was then gradually adjusted for age, sex and edentate status (Model 2), household wealth and education (Model 3), and GDP per capita (Model 4). The latter model reflects the association between Gini coefficient and use of dental services after controlling for compositional and contextual confounders. We then proceeded to assess the individual

and joint contribution of the four indicators of investment in healthcare to explaining the association between Gini coefficient and use of dental services, namely dental health system (Model 5A), total health expenditure (Model 5B), public expenditure on health (Model 5C) and health system responsiveness (Model 5D). Model 5E controlled for all four indicators simultaneously. Their contribution was assessed by calculating the percentage reduction in odds ratio (OR) for the effect of Gini coefficient on use of dental services: 1-[$\ln OR_{Model\ 5}/\ln OR_{Model\ 4}$] (Singh-Manoux et al., 2006).

RESULTS

We analyzed data from 223,299 adults in 66 countries (78% of the total sample of WHS participants in those countries), covering the 6 WHO regions (7 countries in the Americas, 16 in Africa, 4 in South-East Asia, 30 in Europe, 6 in Western Pacific, and 3 in Eastern Mediterranean). Table 1 shows the individual- and country-level characteristics of our sample. Overall, 16.4% of adults used dental services in the past year to address dental needs, ranging from 4.7% in Ethiopia to 40.9% in Slovakia. All indicators of investment in healthcare were significantly related to Gini coefficient (Table 2).

Table 3 presents the estimates for the association between country-level Gini coefficient and use of dental services, after sequential adjustment for various individual- and country-level factors. In the unadjusted model (Model 1), a 10%-increase in Gini coefficient was associated with a 26%-decrease in the odds of using dental services (OR: 0.74, 95% CI: 0.60-0.88). This association was attenuated but remained significant after incremental adjustments for individual-level (Models 2 and 3) and country-level confounders (Model 4). Every 10%-increase in Gini coefficient corresponded with 15% lower odds of using dental services after adjustment for confounders (OR: 0.85, 95% CI: 0.70-0.99). When tested, the interaction between Gini coefficient and GDP per capita was not significant. The individual role of different indicators of investment in healthcare was assessed in Models 5A-5D. The association between Gini coefficient and use of dental services was further attenuated and became non-significant after individual adjustment for dental health system, total health expenditure, public expenditure on health and health system responsiveness. The OR for Gini coefficient attenuated from 0.85 in Model 4 to 0.97 in Model 5E, suggesting that the four indicators together explained 80% (=1-[-0.034/-0.166]) of the association between Gini coefficient and use of dental services.

All estimates from the multilevel models adjusted for confounders (Model 4) and additionally for the four indicators of investment in healthcare (Model 5E) are shown in Table 3. At individual level, the

odds of using dental services were higher in female, middle age, dentate and more educated adults as well as in wealthier households. At country level, the odds of using dental services were higher in countries with mixed dental health system while they increased with decreasing GDP per capita and increased public expenditure on health and health system responsiveness (Table 4).

Sensitivity analysis was performed to assess the influence of the time frame chosen for Gini coefficient and GDP per capita. First, we excluded 8 countries where the Gini coefficient corresponded to years outside the period 2000-2004. Second, we replaced GDP per capita in 2000 with that for 2002 and the average of GDP per capita for the period 1994-2005 (to match the time frame for the Gini data). The results were not sensitive to these changes. Finally, similar conclusions were obtained in sub-group analysis excluding those without dental needs (Appendix Table 3).

DISCUSSION

This study shows that there is a greater use of dental services in more egalitarian countries (as measured by the Gini coefficient). This association was not explained away by a number of confounders acting at individual (demographic and socioeconomic factors) and country-level (national income). Furthermore, this study shows that investment in healthcare may play an important role in explaining the association between income inequality and use of dental services.

Some limitations of this study need to be addressed. First, this study is based on cross-sectional data, and thus, not able to test for causal relationships. Although our findings suggest that investment in healthcare could mediate the association between income inequality and use of dental services, they should be confirmed with longitudinal data. Second, the countries that participated in the WHS were selected based on willingness to participate and they are not representative of the entire world population. However, the countries selected still covered the 6 WHO geographical regions. More importantly, this is the largest multilevel dental study to date, based on data from 66 countries. Third, our measure of use of dental services referred to whether the respondents sought treatment for their particular dental need in the past year. This criterion does not account for dental visits for regular check-ups or preventive measures which are increasingly encouraged by health services, especially among rich countries. Our definition could have masked even greater inequality as population of higher socioeconomic position might have been utilizing services more often than the rest. Finally, our analysis was constrained by data availability. Only one of our four indicators for investment in

healthcare was directly related to dental spending. There is a scarcity of data on dental care expenditure particularly for low and middle income countries. The commonly used dentist-to-population ratio reflects manpower distribution not dental spending.

The magnitude of the effect of income inequality on use of dental services was such that the proportion of adults who used dental services in the last 12 months decreased by 15% for every 10%-increase in country-level Gini coefficient. Consistent with the income inequality hypothesis, the effect of income inequality was stronger than the effect of national income on use of dental services. Importantly, this effect was not only limited to rich countries but was found across all countries evaluated regardless of their stage of economic development (no significant interaction between Gini coefficient and GDP per capita). This is not surprising as dental services in low and middle income countries are mostly provided privately with limited role of public dental health services, which discourages the poor population from using services (Masood et al., 2015). Our findings show the existence of considerable social inequalities in use of dental services within and between countries and that uptake of services is related not only to how much money people have in their pockets (absolute income) but also to how income is distributed in a society (relative income). They also support the Behavioral Model of Health Service Use whereby people's use of health services is a function of individual and contextual characteristics (such as income inequality) which encourage or impede use and need for care (Andersen, 2008). We also found that higher national income was associated with lower dental services use when investment in healthcare was held constant across countries. This is a phenomenon called negative confounding (MacKinnon et al., 2000), suggesting that investment in healthcare is a strong pathway from national income to dental services use.

Our second finding was related to the potential mediating role of investment in healthcare in the relationship between income inequality and use of dental services. The fact that public expenditure on health but not total health expenditure (public plus private) was related to use of dental services in the fully adjusted model emphasizes the view that government investment may be more important to move from potential to realized access to dental care. Health system responsiveness and the type of dental health system were also related to both income inequality and use of dental services. We can then speculate that use of dental services is higher in more egalitarian countries because they invest more in healthcare. Taken together, our findings suggest that it is not only about fairness in financial contribution but also the way in which individuals are treated and the environment in which they are

treated (Valentine et al., 2003; WHO, 2000). This is supported by a recent study where the perception of population on the quality of health care on offer was influenced by income inequality (Nikoloski and Mossialos, 2013). Making health systems more responsive to the legitimate expectations of potential users about non-health enhancing aspects of care may ameliorate the negative impact of income inequality on health services utilization. Interestingly, use of dental services was higher in government-supported dental systems (taxation, social insurance or mixed) than in private systems (at least in the bivariate models), which suggests that moving away from out-of-pocket payments to prepayment and risk-pooling mechanisms is likely to be beneficial (Masood et al., 2015). The fact that only countries with mixed system had higher services use than those with private system in the fully adjusted model may be explained by the inclusion of public expenditure on health in that model, which overlaps more closely with social insurance and taxation system than with the mixed system.

Our findings have some implications for policy and research. They show that government investment in health and dental care may be a way to address the effects of income inequality on use of services and subsequently the health of the population. They also add to current debate on universal coverage and the search for alternative healthcare financing strategies and policies to improve fairness in financial contribution. As for research, this area would benefit from further studies exploring the individual and combined roles of alternative mechanisms in the relationship between income inequality and use of dental services, especially the effect of social capital and psychosocial stress.

In conclusion, this multilevel study across 66 countries showed that income inequality was associated with use of dental services. There was also evidence for the role of investment in healthcare as a potential mechanism linking greater income inequality to lower use of dental services.

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Table 1: Individual and country-level characteristics of the study sample (n=223,299)

Level 1: Individual (n=223,299)	**n**	**%**	**% use of dental services**
Sex			
Women	124,508	55.8	17.8
Men	98,791	44.2	14.5
Age groups			
18-29 years	63,998	28.7	13.6
30-39 years	52,795	23.6	16.6
40-49 years	40,194	18.0	18.3
50-59 years	27,401	12.3	19.9
60-69 years	20,944	9.4	18.0
70+ years	17,967	8.1	14.1
Edentate status			
No	205,185	91.9	16.3
Yes	18,114	8.1	17.3
Household wealth			
1st tertile (lowest)	82,557	37.0	12.6
2nd tertile (middle)	70,914	31.8	16.7
3rd tertile (highest)	69,828	31.3	20.6
Education			
Primary school	120,858	54.1	12.1
Secondary school	81,534	36.5	19.5
College or above	20,907	9.4	29.0
Level-2: country (n=66)	**n**	**%**	
Dental health system			
Private provision	41	62.1	
Mixed	6	9.1	
Social insurance	14	21.2	
Taxation	5	7.6	
	Mean	**(SD)**	**Range**
Gini coefficient (%)	41.6	(8.5)	24.7-64.3
GDP per capita (US$)[a]	4,092.5	(6,698.4)	123-46,453
Total health expenditure (% GDP)	5.8	(1.9)	2.0-11.1
Public expenditure on health (%)	48.0	(17.0)	23.9-90.8
Health system responsiveness (0-10)	5.2	(0.8)	3.7-7.4

[a] GDP: Gross Domestic Product

Table 2. Correlations between Gross Domestic Product (GDP) per capita, Gini coefficient (GINI), total health expenditure (THE), public expenditure on health (PEH), health system responsiveness (HSR) and type of dental health system (DHS) at country level (n=66 countries)

Measures[a]	**GDP**	**GINI**	**THE**	**PEH**	**HSR**	**DHS**
GDP	1.000					
GINI	-0.478***	1.000				
THE	0.624***	-0.326**	1.000			
PEH	0.650***	-0.542***	0.435***	1.000		
HSR	0.873***	-0.448***	0.643***	0.625***	1.000	
DHS	0.680***	-0.713***	0.623***	0.734***	0.707***	1.000

[a] Pearson's correlation coefficients are reported in all cases except DHS (1=private provision, 2=mixed, 3=social insurance, 4=taxation) for which polychoric correlation coefficients are reported
** p<0.01; *** p<0.001

Table 3. Change in the odds ratio (OR) of using of dental services for a 10% change in the country-level Gini coefficient with a sequential introduction of a range of individual- and country-level factors (n=223,299)

Models[a]	Estimate (SE)		OR [95% CI]		Between Country variance (SE)	
Empty model					0.387	(0.067)
Model 1	-0.297	(0.071)	0.74	[0.60-0.88]	0.302	(0.053)
Model 2	-0.299	(0.072)	0.74	[0.60-0.88]	0.308	(0.054)
Model 3	-0.246	(0.066)	0.78	[0.65-0.91]	0.256	(0.045)
Model 4	-0.166	(0.074)	0.85	[0.70-0.99]	0.252	(0.045)
Model 5A	-0.091	(0.074)	0.91	[0.77-1.06]	0.216	(0.038)
Model 5B	-0.157	(0.072)	0.85	[0.77-1.00]	0.235	(0.042)
Model 5C	-0.057	(0.072)	0.94	[0.80-1.09]	0.209	(0.037)
Model 5D	-0.126	(0.068)	0.88	[0.75-1.01]	0.236	(0.042)
Model 5E	-0.034	(0.066)	0.97	[0.84-1.10]	0.161	(0.029)

[a] Model 1 was unadjusted; Model 2: Model 1 plus adjustments for age, sex and edentate status; Model 3: Model 2 plus adjustments for education and household wealth; Model 4: Model 3 plus adjustment for GDP per capita; Model 5A: Model 4 plus adjustment for dental health system; Model 5B: Model 4 plus adjustment for total health expenditure; Model 5C: Model 4 plus adjustment for public health expenditure; Model 5D: M4 plus adjustment for health system responsiveness; and Model 5E: Model 4 plus adjustment for all indicators of investment in healthcare.

Table 4. Association of use of dental services with individual- and country-level factors (n=223,299)

Explanatory Variables	Unadjusted	Model 4[a]	Model 5A[a]
	OR [95% CI]	OR [95% CI]	OR [95% CI]
Individual-level factors:			
Sex			
Women	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Men	0.84 [0.82-0.86]	0.81 [0.79-0.83]	0.81 [0.78-0.83]
Age group			
18-29 years	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
30-39 years	1.19 [1.16-1.22]	1.20 [1.17-1.23]	1.21 [1.17-1.24]
40-49 years	1.23 [1.19-1.26]	1.25 [1.22-1.29]	1.26 [1.22-1.30]
50-59 years	1.29 [1.26-1.33]	1.39 [1.36-1.43]	1.40 [1.36-1.44]
60-69 years	1.09 [1.05-1.13]	1.28 [1.24-1.33]	1.29 [1.24-1.33]
70+ years	0.76 [0.71-0.81]	0.99 [0.94-1.04]	1.00 [0.94-1.04]
Edentate status			
No	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Yes	0.76 [0.72-0.80]	0.85 [0.80-0.90]	0.85 [0.80-0.90]
Household wealth			
1st tertile (lowest)	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
2nd tertile (middle)	1.33 [.130-1.36]	1.27 [1.24-1.30]	1.27 [1.24-1.30]
3rd tertile (highest)	1.73 [1.71-1.76]	1.56 [1.53-1.59]	1.57 [1.54-1.60]
Education			
Primary school	1.00 [Reference]	1.00 [Reference]	1.00 [Reference]
Secondary school	1.39 [1.36-1.42]	1.26 [1.23-1.30]	1.27 [1.23-1.30]
College or above	1.82 [1.78-1.86]	1.51 [1.46-1.55]	1.51 [1.47-1.56]
Country-level factors:[b]			
Gini coefficient	0.74 [0.60,0.88]	0.85 [0.70-0.99]	0.97 [0.84-1.10]
GDP per capita	1.14 [1.08-1.21]	1.08 [1.02-1.15]	0.86 [0.75-0.97]
Dental health system			
Private	1.00 [Reference]		1.00 [Reference]
Mixed	2.00 [1.53-2.47]		1.59 [1.22-1.96]
Social insurance	2.40 [2.07-2.73]		1.28 [0.94-1.63]
Taxation	1.88 [1.36-2.39]		1.01 [0.47-1.55]
Total health expenditure	1.14 [1.08,1.21]		1.04 [0.98-1.10]
Public expenditure on health	1.22 [1.16,1.28]		1.10 [1.03-1.18]
Health system responsiveness	1.54 [1.40,1.69]		1.50 [1.27-1.73]

[a] Model 4 was adjusted for age, sex, edentate status, education, household wealth and GDP per capita; and Model 5A additionally adjusted for dental health system, total health expenditure, public health expenditure and health system responsiveness.

[b] Gini coefficient assessed by 10%-increase, GDP per capita by US$5,000-increase, total health expenditure by 1%-increase, public expenditure on health by 10%-increase and health system responsiveness by 1-unit increase.